

What is claimed is:

Sub a'

1. A method for controlling the quantization in a digital video encoder that comprises a plurality of parallel compression engines, comprising the steps of:

determining a target quantization level for a video frame;

wherein the video frame is represented by a plurality of panels, each panel comprises a plurality of slices, and each panel is processed in parallel by a respective one of the compression engines;

encoding the first slice of each panel in accordance with said target quantization level; and

encoding subsequent slices in each panel in accordance with a quantization level that is allowed to vary from said target quantization level until the last slice of each panel is reached;

wherein the quantization level used for encoding the last slice of each panel is driven toward said target quantization level.

2. A method in accordance with claim 1 wherein said driving step uses piecewise linear feedback to drive the quantization level of the last slice of each of said image panels toward said target quantization level.

3. A method in accordance with claim 2 wherein said feedback avoids abrupt variations in the quantization level between the first and last slice of each of said image panels.

4. A method in accordance with claim 1 wherein a group of pictures (GOP) target bit rate is adjusted based on a number of film pictures and non-film pictures currently in a processing pipeline of at least one of said compression engines.

5. A method in accordance with claim 4 wherein a higher target bit rate is provided for non-film pictures.

6. A method in accordance with claim 1, wherein: the quantization level used for encoding the last slice of each panel is driven toward said target quantization level such that the first slice and the last slice of each panel are encoded in accordance with approximately the same quantization level.

7. A method in accordance with claim 1 wherein a buffer level of said video encoder is used to control the start of a new group of pictures (GOP).

8. A method in accordance with claim 1 wherein said panels are simultaneously compressed at the respective compression engines during a frame time.

9. A method in accordance with claim 8 wherein the compressed panel data are stored locally at the compression engines for subsequent transfer to a video buffer of the video encoder within a next frame time.

10. A method in accordance with claim 9 wherein data are retrieved from said buffer, to form a transport packet, at an average rate equal to a specified video bit rate whenever the buffer has at least one transport packet payload's worth of data.

11. A method in accordance with claim 10 wherein null packets are substituted for video packets to maintain a constant transport bit rate whenever said buffer level falls below one transport packet payload's worth of data.

12. A method in accordance with claim 7 wherein a reference quantizer scale is calculated for each of said compression engines.

13. A method in accordance with claim 12 wherein the reference quantizer scale for a compression engine is calculated based on:

an accumulation of quantizer scale values for that compression engine (sum_quant),

an accumulation of the number of bits generated on that compression engine (bitcount);

an accumulation of the number of macroblocks processed on that compression engine (MBcount); and

a fullness level of a video buffer of the video encoder (buffer_level).

14. A method in accordance with claim 13 wherein the compression engine modifies its reference quantizer scale based on a local buffer fullness to generate a final quantizer scale value for use in quantization.

15. A method in accordance with claim 14 wherein a panic mode is initiated by the compression engine if the final quantizer scale value is higher than a predetermined maximum value, said panic mode maintaining the quantization at or below said predetermined maximum value.

16. A method for controlling the rate at which data is processed by a digital video encoder using a plurality of parallel compression engines to compress successive macroblocks of video data, comprising the step of:

providing macroblock level rate control in accordance with a rate control interrupt service routine a plurality of times per coded picture as the video data is being compressed at the respective compression engines.

17. A method in accordance with claim 16, wherein:

quantizer scale values at the compression engines are adjusted at interrupts of the rate control interrupt service.

18. A method in accordance with claim 16, comprising the further step of:

providing frame level rate control on successive video frames in accordance with a picture start interrupt service routine once per coded picture.

19. A method in accordance with claim 18 wherein said picture start interrupt routine updates frame level statistical variables by processing data collected from a prior coded frame.

20. A method in accordance with claim 16 comprising the further step of calculating a target bit rate for a new group of pictures (GOP) if a new frame to be processed comprises an intra-coded (I) frame.

21. A method in accordance with claim 16 comprising the further steps of:

calculating upper and lower limits on the number of bits that a new frame is allowed to generate for every frame to be encoded; and

computing a target number of bits to be generated for each frame and for each of a plurality of panels into which each frame is divided.

22. A method in accordance with claim 21 wherein said target number of bits is computed by distributing the bits in proportion to relative complexity values of the video frames being processed.

23. A method in accordance with claim 21 wherein said rate control interrupt service routine provides interrupts as the video data is being compressed at the respective compression engines which initiate a modulation of a frame target quantizer scale, said modulation being based on feedback to attempt to bring

09806326 "040201

the actual number of bits for each of said panels to the corresponding target number of bits for the panel.

24. A method in accordance with claim 21 comprising the further step of calculating a frame target quantizer scale from the target number of bits computed for a frame.

25. A method in accordance with claim 24 wherein said frame target quantizer scale is provided to each of said plurality of compression engines as an initial reference quantizer scale for use in commencing coding of the video frame.

26. A method in accordance with claim 25 wherein said macroblocks comprise DCT coefficients, said method comprising the further step of:

enabling said compression engines to force some of said DCT coefficients to zero if said reference quantizer scale is too high to maintain the number of bits that the new frame is allowed to generate within said upper limit.

27. Apparatus for controlling the quantization in a digital video encoder that comprises a plurality of parallel compression engines, comprising:

means for determining a target quantization level for a video frame;

wherein the video frame is represented by a plurality of panels, each panel comprises a plurality of slices, and each panel is processed in parallel by a respective one of the compression engines;

means for encoding the first slice of each panel in accordance with said target quantization level; and

means for encoding subsequent slices in each panel in accordance with a quantization level that is

allowed to vary from said target quantization level until the last slice of each panel is reached; and

means for driving the quantization level at the last slice of each of said image panels toward said target quantization level.

28. Apparatus for controlling the rate at which data is processed by a digital video encoder using a plurality of parallel compression engines to compress successive macroblocks of video data, comprising:

means for providing macroblock level rate control in accordance with a rate control interrupt service routine a plurality of times per coded picture as the video data is being compressed at the respective compression engines.

29. An apparatus in accordance with claim 28, further comprising:

means for providing frame level rate control on successive video frames in accordance with a picture start interrupt service routine once per coded picture.

30. An apparatus in accordance with claim 28, further comprising:

means for adjusting quantizer scale values at the compression engines at interrupts of the rate control interrupt service.